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Information Exploitation Office (IXO)
IXO Overview

Bob, thank you for the introduction. You are doing a great job at DARPATech but don't forget, you promised me you wouldn't volunteer for next time.

Good afternoon everyone. It's a pleasure to be the after lunch wake up speaker, and to tell you about our new Information Exploitation Office, IXO.

The United States must be prepared to face a variety of threats at home and abroad from challenging opponents. We can predict some of these threats now but must be prepared for unforeseen events that may result in the need to employ our military power. Future U.S. military actions may often require rapid, dominant, decisive operations by combined space, air, sea and land forces. We must be able to immediately counter any threat, control the operational tempo, and defeat our opponents in detail. We must possess the capability to conduct military operations autonomously, with or without reliance on partners.

The goal of our office is straightforward. We want to be able to find and neutralize any adversary that attempts to operate on the land battlefield, and, we want to do this with precision. That is in a manner that minimizes unintended consequences, such as collateral damage and undesired casualties.

The good news for our office is that the Department of Defense now recognize the major impact command, control, communications, computing, intelligence surveillance and reconnaissance (which is abbreviated as C4ISR) has on battlefield effectiveness. Rather than treat C4ISR as an afterthought, the Department of Defense now realizes the major benefits C4ISR brings to our warriors. Even the President has recently talked about the benefit of continuously locating, tracking, and killing moving threat targets. Moving targets are one of IXO's key focus areas.

Now let's look at what the term "Information Exploitation" means, particularly to a technologist. We are not simply talking about generating more data to swamp Warfighters. We are talking about generating, disseminating and enabling the Warfighter to act on information. We are talking about a transformation to network-centric and information-centric warfare that enables our Warfighters to outmaneuver and outshoot their opponents in the information space as well as in the battlespace.

We are going to tightly couple the C4ISR process with the Kill process. We call this C4KISR.

The slide contains some obvious C4KISR needs. First, you can't attack targets if you can't find them. In addition, under restrictive rules of engagement, you need to find and precisely identify targets before you can attack them. We need better sensors and better sensor exploitation to do this.

The next obvious point is that you can't kill mobile targets if your command and control systems are too slow. If there is a long time duration between the time a Warfighter finds a target, and the time the target is attacked, you're giving the target too much of a chance to escape and hide. So, we need dynamic command and control, faster weapons and better weapons.

Finally, in this era of network centric warfare, you can't share information if you don't have the tools. This includes the radio communications networks and the computer-to-computer capabilities for semantic integration of information and collaboration.

So, IXO's goal is to solve these problems. We are going to work this problem end-to-end—from the sensor, to the decision, to the kill, to the battle damage assessment process, and back to the sensor.

Our problem for C4KISR is complicated. Our future opponents have watched how we operated in past military operations and we need to be aware of what they may have learned. Further complicating life is the

fact we are faced with a broad spectrum of threat targets ranging from the traditional long-range mobile missile and armor to commercial trucks with mounted weapons. We also have to deal with dismounted combatants in many military missions. Unfortunately, we do not have a single solution in mind for all threats and all situations. We believe we need a diverse set of technological solutions for a diverse set of targets and situations.

Our office can't afford to solve all of today's information exploitation problems. So, we plan to focus on two of the mission areas: precision air-to-ground strikes and precision ground combat in the context of constrained rules of engagement.

Our version of the Observe, Orient, Decide and Act loop—the so-called OODA loop—for C4KISR is a set of ten functions. Some of these functions form what we call the kill chain and are shown on the right side of the chart: searching and finding targets, tracking targets and identifying targets, deciding to engage targets, maintaining identification on the target while verifying compliance with the rules of engagement, attacking the target, and then performing battle damage assessment of the engagement.

Concurrently, two major functions shown on the left side must be performed. The global situation must be constantly developed and assessed and operational plans must be developed and executed.

All of these functions are simultaneously supported by an important infrastructure function. Together, these functions provide a model for C4KISR, which we find useful in analyzing operational needs, recognizing performance shortfalls and defining, organizing and demonstrating our technology development programs. Although this not a large number of functions, one must appreciate that these functions are simultaneously performed against a multitude of targets and missions and in a variety of different threat and background conditions.

One must also visualize that typically, these functions are implemented in a network comprised of a set of specific sensors, sensor platforms, processing centers, command and control relationships, weapon delivery systems and munitions, all focused on a variety targets. These networks must be constructed and operated to synergistically utilize all of the available assets. Whenever a target is detected and selected for engagement, the best mix of these networked assets must be temporarily assembled to implement the engagement sequence.

As an example of such a network in action, we might have Global Hawk platforms at high altitude, the Joint STARS aircraft at medium altitude, and unattended ground sensors (UGS) on the ground, all cooperatively working to search and find targets. Global Hawk, Joint STARS, a Joint Strike Fighter, and the UGS might then track the target. Concurrently, a Predator at medium altitude with a 3-D imaging ladar could provide precision identification. Lastly, a Joint Strike Fighter flight might engage the target and the Predator could perform battle damage assessment.

We have spent considerable effort analyzing the ability of our existing C4ISR systems to support future conflicts and in determining the types of capabilities needed for the future. In particular, we have attempted to identify those capabilities that would support transformation of the force. I will share our conclusions with you by walking through the major C4KISR functions.

First let's look at the kill chain and the initial function: Search/Find. We need to be able to search for any type of target in any terrain at any time. This includes searching for weapons of mass destruction and searching for dismounted combatants. Further, we need to take the humans out of the loop. Our sensor and automated or semi-automated exploitation systems have improved considerably in the last decade, but the false alarm rates remain too high to be operationally useful for the system we have in mind.

We need ubiquitous multi-disciplined sensing to find targets no matter what their situation or hide state. We need multiple platforms to give us complimentary target observations. We need multi-mode sensors such as UHF and X-band synthetic aperture radars (SAR), which, operating on the same platform, could perform coherent or incoherent change detection in the UHF mode, and then cue the X-band mode for

high-resolution synthetic aperture imaging. Of course we need to be able to automatically interpret the data from these sensors and combinations of sensors.

We in IXO envision a day when we have "ubiquitous sensing," where no target will be able to move or deploy on the battlefield without observation. No matter where the threat moves, there will always be an appropriate sensor staring the target in the face, unless, of course, the target goes into deep hide.

By "appropriate," I mean, for example, that if the threat is in foliage, we will have a foliage-penetrating sensor. Our goal is to extend the ubiquitous sensing notion to ubiquitous C4KISR, by which I mean a seamless web of sensors, exploitation, C2 and weapons linked to commanders and executors. The C4KISR web will ensure that an appropriate sensor is always watching the adversary, and the appropriate platforms and weapons are positioned to kill him as we wish.

We have several current projects that address this area. We have VHF/UHF SAR for imaging targets in foliage. We are collecting data at field test sites now, with plans to conduct an operational demonstration next year. This summer we are demonstrating our Advanced Tactical Targeting Technology (AT3) for precise location of agile, pulsed emitters for support of suppression of enemy air defense missions. We are one year away from an operational demonstration of unattended ground sensors for detecting and locating vehicles.

Once we find targets we need to track their movement or watch their hide site for future activity. We have a major program in terminal target tracking and attack—AMSTE. The acronym stands for affordable moving surface target engagement. It uses multiple moving target indicator (MTI) mode radars to achieve very accurate target position estimation through multi-lateration. This capability is coupled with a feature-aided tracker that provides the ability to track a target moving through extensive background traffic clutter. AMSTE closes the kill chain by continuously steering GPS guided munitions onto a moving target. This program really puts the Kill into C4KISR.

As I mentioned, precise target identification is a challenge. We currently have no target identification technology that can compete with the precision identification capability of human eyeballs. Consequently, precision target ID currently is limited by the skill and availability of humans.

A particular problem for automated systems is targets utilizing countermeasures and target types that have never been seen before. Of equal concern are targets, which have undergone modifications since they were last observed. We need to have automated systems that can adapt to these targets and target changes. Higher dimensional sensing, including multi-discipline, multi-polarization and higher resolution sensing, is part of the answer. We also need automated target recognition capabilities that recognize the fundamental target components like turrets, gun barrels and tracks and thereby synthesize the functionality and identification of the target.

Two of our new sensor programs are developing both a short range and a standoff 3-D ladar for high-resolution 3-D imaging. The short-range version, called Jigsaw, allows the sensor to penetrate gaps in foliage and artificial camouflage using many pulses to obtain diverse views of the target. The standoff version is for moving and stationary targets in the open. Both sensors provide very high quality images, 3-inch resolution in 3 dimensions, for precise target identification. Once we have found a target, tracked it enough to estimate its position, and identified it, we can then decide whether we should engage it. This decision is facilitated by the capability to rapidly verify that if we engage we will have complied with the rules of engagement. We must rapidly determine that there is an appropriate weapons carrier available. When selecting a weapon carrier, such as an F-15E fighter-bomber, we must assess whether the diversion of the weapons carrier from another target is the appropriate action in the context of the overall campaign.

Once the engagement commences, there is a need to maintain the identification of the target and ensure that conditions don't change which would violate the rules of engagement. An elusive target may mix with civilian traffic on the roads making it difficult to maintain precise target track or it may merge into a situation that violates the ROE and even a Geneva Convention rule such as nudging up to a hospital. We need

algorithms and supporting sensor capabilities to enable continuous tracking across multiple sensors and sensor platforms to maintain the target identity or to re-identify the target.

When we actually engage a moving target, we need to be able to update the munitions aim point continuously. We may do this with off board sensors and affordable weapon data links or affordable autonomous intelligent seekers that can not only find targets but also verify ROE compliance.

We need to be able to assess the outcomes of engagement immediately so we can reengage if necessary. If we allow the normal "battle damage assessment" process to occur, we will most likely lose track and the identity of any surviving mobile target. We need to be able to discern the type of damage, especially the subtle damages that we create with our modern precision munitions.

The kill chain I just described goes on simultaneously against many targets, in many different parts of the battlespace. Tomorrow's multi-role weapon systems will allow an individual platform to support many different engagements. So we need to orchestrate the activities of all the platforms present—synchronizing sensing with strike with and even with ground maneuver activities.

There are two parts to this orchestration I just mentioned. First, we must anticipate the future, so that we stay ahead of the opponents. We can sense what they're doing now and what they have done in the past. From that, we need to infer how they're organized, and what their goals may be. From that, we can automatically construct potential courses of action that the threat may follow. Of course, we'll never be able to predict exactly what the threat will do, but we can understand what their best options are, and do contingency planning to deal with whichever option the threat chooses. We can also anticipate their reactions to our actions, and thus nominate targets that anticipate the threat's workarounds. This is an essential element of true effects-based planning.

We need to shape the battlespace to accomplish our objectives through sensing, maneuvering, and judicious application of firepower. This means controlling the future—by building and revising tactical plans to take advantage of new opportunities such as newly discovered critical mobile targets. We want to synchronize wide area search sensors with narrowly focused ID sensors, so that we can maintain track and ID on critical targets. We want to synchronize sensors with strike, so that we can avoid losing kill opportunities.

A major challenge here is that military tactics evolve faster than our decision support systems. We need technology that can immediately capture the tactical innovations of our warfighters, and make those innovations available to everyone—without having to rewrite software. So we need to capture new tactical plans as they are built, and incorporate them into on line tactical "playbooks".

One of our success stories is our Active Templates project, which delivered several planning tools for special operations forces. This technology captures a complete plan—including dependencies among different plan threads for a tactical operation—so that one part can be modified and others automatically adjusted to retain consistency.

We have a collection management program to maximize the value collected by a constellation of sensors. This includes determining near optimal collector trajectories and sensor schedules. We are deploying Battlebooks, portable computers that support continuous collaborative planning in ground operations, to the Army's Striker Brigade Combat Teams. And we have a program to develop technology for routing and scheduling cooperative teams of automated platforms.

Finally, we need an infrastructure of communications, embedded computing, and information dissemination to tie together all of the sensing, exploitation, and C2 applications I've just mentioned. Here, one of our objectives is to eliminate monolithic software systems and replace them with reconfigurable information systems that can adapt to new situations, new organizations, and new command styles. We have three main areas of work in the infrastructure area.

First, communications. Our digital radio frequency tag program, DraFT, provides a tag as well as a communications link. This link is used to direct sensors or other devices, and to exfiltrate data from ground-based entities. We also have a major communications program called Tactical Targeting Network Technology to develop a high throughput network radio for sensor-to-sensor and sensor-to-shooter applications.

Second, scalable and embedded computing. Our Ultralog program is leading the development of agent-based technology to provide secure, scalable, survivable computing foundations for large-scale distributed systems such as logistics management. Our embedded software technology programs are building design tools and real-time middleware systems to actively control processing—reducing delays and increasing reliability and performance.

The third area is translation. Our DARPA agent mark-up language (DAML) program is providing tools and techniques to translate information from one machine to another. Today, it supports markup of intelligence reports that include semantics—basic concepts and relationships—not just keywords. In the future, it will allow different decision aids, agents, or web sites to translate information on the fly.

I could spend the remainder of my time discussing current work. But, just in case there is some contractor here who wants to hear about our future needs and future plans, I'll take a few more minutes on that topic.

We need wide area surveillance sensors and algorithms that have a high probability of finding targets with a false alarm rate of less than 0.1 false alarms per square kilometer. We are very interested in foliage penetrating MTI radars that can detect moving vehicles and personnel. Ideally the MTI radar would exist on a platform that can loiter such as a helicopter or an organic air vehicle so that very low velocity targets can be detected. We're interested in high-dimensional sensing such as ultra-high-resolution (< 10 cm) and/or multi-polarization MTI and synthetic aperture imaging radar for target recognition. Sensors and exploitation aids for precision identification of targets at long ranges (> 10 km) are very important, as are any novel sensors and sensor modes that provide previously unexploited target phenomena.

We have been challenged to deal with dismounted combatants and we are interested in sensors and exploitation aids for detection, tracking and classification of dismounts in complex terrain and in urban areas.

We continue to be interested in aided or automatic target recognition technology and we are seeking out new ideas in this area as well as ways to improve existing techniques. Especially key here is the ability to rapidly insert new targets that have just been seen for the first time.

We need tracking technology that will give us much longer track lives. This might include a combination of adaptive, variable depth, multiple hypothesis tracking and feature-aided tracking.

We want technology for battlespace prediction and dynamic synchronization of sensors, exploitation resources and weapon systems, for both air strike and ground combat. Of course, web-based, network-centric enabling technology would be of interest.

We hope that some of you will have great ideas on these topics. And even though your idea might depart from the topics I've discussed, we would be happy to hear from you.

In summary, the goal of our office is to precisely attack and kill any ground target anywhere at anytime. We have four technical areas: sensors, exploitation, information integration and command and control. We are interested in integrating across those areas to develop a comprehensive capability. Our challenge is to put the kill into C4ISR in order to engage elusive threat targets with high confidence and low collateral damage.

That completes my overview. Five of my colleagues will now go into more detail. Allan Steinhardt will describe countering concealed targets. Tom Strat is going to tell you about precision identification. Bob Tenney will tell you about dynamic battle management. And Steve Welby is going to tell you about network centric sensing and engagement. Finally, to "tie it up" Peter Highnam is going to tell you about data links for networked targeting.